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THESIS

AN APPLICATION OF THE RAYLEIGH DISTRIBUTION
TO
CONTRACT COST DATA

by

Thomas S. Abernethy

September 1984

Thesis Advisor: Dan C. Boger

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Accurate cost models are essential to the proper monitoring of contract cost data. The greater the accuracy of the model, the earlier contract cost overruns can be recognized and their cause(s) ascertained. The availability of a variety of cost models allows flexibility in choosing the correct model for the particular circumstances and increases the chances of being able to select a model that can provide reliable forecasts about future costs.

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This thesis investigates the possibility of adapting the Rayleigh distribution to cost modelling and develops an APL algorithm which summarizes the results of the application of the Rayleigh model to historical contract cost data.

The Rayleigh model was found to be applicable to cost modelling and exhibited some predictive capability in the 21 Navy contracts examined.

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An Application of the Rayleigh Distribution to Contract Cost Data

by

Thomas S. Abernethy
Lieutenant, United States Navy
B.S., United States Naval Academy, 1978

Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

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I. INTRODUCTION

The cost of procurement is an important element in the weapons acquisition decision making process within the Department of Defense. "In the late 1960's, rapidly increasing costs for new weapons systems gave impetus to the use of procurement cost as a design parameter comparable in importance to performance and schedule" [Ref. 1]. Maximization of the number and quality of weapons systems procured in the face of budgetary constraints requires that fiscal resources be used as efficiently as possible. Contract costs are reported and monitored to aid in ensuring that this requirement is met. This monitoring of costs permits identification of cost overruns which adversely affect the efficiency with which fiscal resources are utilized. The earlier cost overruns are identified, the earlier investigative actions can be initiated to isolate and eliminate their cause(s).

Use of the proper model is a prerequisite for the identification of cost overruns. If the model has been proven by analysis of historical data to be applicable to certain types of contracts, identification of cost overrruns in these types of contracts can be made early, their cause(s) corrected early, and the unnecessary expenditure of fiscal resources eliminated early.

This thesis uses historical Navy contract data to determine if the Rayleigh model can be applied to contract cost streams, and develops an algorithm for the application of this model to historical contract data.

II. THE RAYLEIGH MODEL

The Rayleigh model described in this chapter is an adaptation of the one used to model manpower utilization in [Ref. 2].

The density function for the Rayleigh model is

$$f(t) = 2*a*t*\exp(-a*t**2), \qquad \text{(eqn 2.1)}$$

and the cumulative density function is

$$F(t) = 1-\exp(-a*t**2), \qquad \text{(eqn 2.2)}$$

where

a = Rayleigh shape parameter, and

t = time elapsed since contract start.

Examples of a Rayleigh density and cumulative density function are displayed in Figure 2.1. Multiplying Equation 2.2 by K, the Rayleigh scale parameter (total contract cost), yields an equation which specifies how cumulative contract cost, C, varies with time, i.e.

$$C(t) = K*(1-\exp(-a*t**2)). \qquad \text{(eqn 2.3)}$$

Since Equation 2.1 is the derivative of Equation 2.2 with respect to time, multiplying Equation 2.1 by K yields an equation specifying how the rate of change of cumulative contract cost varies with time, i.e.

CDOT = c(t) = 2*K*a*t*exp(-a*t**2). (eqn 2.4)

Each different a,K pair characterizes a different cost distribution.

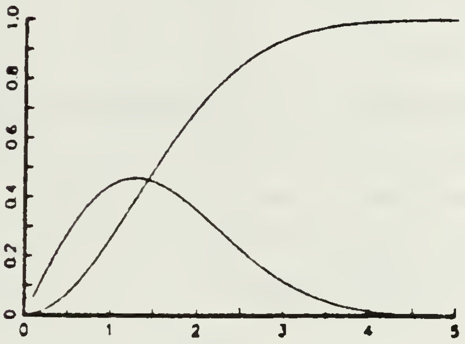

Figure 2.1 Rayleigh PDF and CDF, a = .3

Transformation of Equation 2.4 yields an expression which is linear in terms of t**2, where t**2 is the abscissa and ln(CDOT/t) is the ordinate. The transformation proceeds as follows:

C(t) = K*(1-exp(-a*t**2)) (eqn 2.5)

CDOT = (dC(t)/dt) = 2*K*a*exp(-a*t**2). (eqn 2.6)

Dividing by t yields,

(CDOT/t) = 2*K*a*t*exp(-a*t**2). (eqn 2.7)

Taking the natural logarithm yields,

$$\ln(CDOT/t) = -a*(t**2)+\ln(2*K*a). \qquad \text{(eqn 2.8)}$$

This equation, if the abscissa is t**2, is linear of the form Y = AX+B, where

Y = ln(CDOT/t),

A = -a, and

B = ln(2*K*a).

Thus, the Rayleigh shape and scale parameters can be estimated for any cost stream by performing linear regression on the transformed reported costs and their associated times since contract start. The regression will permit estimation of the values of a and K, where

a = -(slope) = -A, and

K = (exp(intercept))/(-2*slope) = (exp(B))/(-2*A).

III. DATA PROCESSING

A. DATA ACQUISITION

In order to examine the appropriateness of the Rayleigh model, suitable Department of Defense contract cost data had to be procured. As the search through the Department of Defense progressed, it became apparent that there was no single computer file in which all past and present contract cost data was kept. The data search ended when the Office of the Assistant Secretary of Defense, Comptroller, graciously supplied a computer printout containing some Navy contract data.

The data package consisted of historical cost information on 110 completed Navy contracts. Each contract was headed by the following items:

1) Contract Number,
2) Contract Type,
3) Start Date,
4) Cost Structure, and
5) Manufacturer.

The body of the contract report consisted of a column of report dates, each accompanied by the following entries.

1) RBCWS - Reported Budgeted Cost of Work Scheduled.
2) BCWS - Budgeted Cost of Work Scheduled.
3) RBCWP - Reported Budgeted Cost of Work Performed.
4) BCWP - Budgeted Cost of Work Performed.
5) ACWP - Actual Cost of Work Performed.
6) MR - Management Reserve.
7) TARGET - Target Cost.
8) TOTAL ALLOCATED BUDGET.
9) EAC - Contractor's Estimate of Cost at Completion.

10) PMEST - Program Manager's Estimate of Cost at Completion.

11) COMPLETION DATE - Expected Completion Date.

All dollar entries were in units of then year millions of dollars.

B. DATA SCREENING

Use of all of the information on each contract was not necessary to determine whether or not the actual costs could be accurately characterized by a Rayleigh distribution. Only a contract's start date, report dates, and ACWPs were required for this. The ACWPs were cumulative contract costs in units of current year millions of dollars as of the acccompanying report date, and were reported on a quarterly basis.

Each contract chosen for analysis met two criteria. Every contract selected was of at least three years' duration in order to have a cost stream long enough to permit examination of the predictive value of the Rayleigh model. In addition, every contract selected had nondecreasing ACWPs throughout its life to prevent confounding of the cost stream by decreasing ACWPs.

The 21 contracts in Table 1 satisfied these constraints, and the format of their reduced data is shown in Figure 3.1. For every contract, the first date in the first column was the contract start date, therefore the ACWP at this point was always zero. Each succeeding date was a report date for the corresponding ACWP.

C. ESTIMATION OF RAYLEIGH PARAMETERS

The first step in the estimation of the Rayleigh parameters from a a contract's cost data, which is generically displayed in Figure 3.1, was to change the calendar dates into numbers. The lives of all 21 contracts selected were contained in the interval between 1OCT73 and 31MAR86, an

TABLE 1

Contracts Analyzed

Contract	ID Number	Program
1	N00024-76-C-6050	CAPTOR MINE
2	N00019-78-C-0146	CH-53
3	N00019-75-C-0424	F-18
4	N00019-76-C-0261	F-18
5	N00024-77-C-2082	FFG-7
6	N00024-76-C-2100	FFG-7
7	N00024-77-C-2081	FFG-7
8	N00019-76-C-0052	HARPOON
9	N00019-77-C-0383	LAMPS III
10	N00019-77-C-0202	LAMPS III
11	N00019-77-C-0201	LAMPS III
12	N00024-77-C-2051	PHM
13	N00024-79-C-6444	TACTAS
14	N00019-76-C-0227	TOMAHAWK
15	N00019-75-C-0080	TOMAHAWK
16	N00019-78-C-0206	TOMAHAWK
17	N00019-78-C-0206	TOMAHAWK
18	N00019-81-C-3103	TOMAHAWK
19	N00024-75-C-2014	TRIDENT I
20	N00024-78-C-2316	CG-47
21	N00024-75-C-2025	AS-39, 40

Date	ACWP
19MAR76	0.0
25AUG76	8.1
25NOV76	14.7
25FEB77	16.9
etc.	etc.

Figure 3.1 Contract Data Format

interval of 12.5 years' or 50 quarters' duration. It was decided to base the time scale on fiscal year quarters starting with quarter number 1 beginning on 1OCT73 and quarter number 50 ending on 31 MAR86. Since each quarter of every fiscal year consists of either 90, 91, or 92 days, computing fractions of a quarter to the nearest hundredth provided a level of precision commensurate with that of the calendar report date. In order to transform the calendar date into a numerical value, the number of the quarter containing the date was determined. Next, the number of days in that quarter that had passed, up to and including this date, were divided by the total number of days in the quarter to yield a fraction. The sum of the quarter number and the fraction was a numerical representation of the calendar date. The following is an example of this process.

19MAY76
MAY76 is in quarter number eleven.
19MAY is day 49 of this quarter.
There a total of 91 days in this quarter.
49/91 = .54
11+.54 = 11.54
19MAY76 is numerically represented by 11.54.

The information shown in Figure 3.1 is displayed in Figure 3.2 after replacing the calendar dates with their numerical representations. For each of the 21 contracts, two columns like those in Figure 3.2 were entered into an APL workspace.

Date	ACWP
10.87	0
12.61	8.1
13.61	14.7
14.62	16.9
etc.	etc.

Figure 3.2 Contract Data Format

The next step was to convert the ACWPs from then year dollars to 1972 dollars. The APL function in Figure 3.3

utilized the conversion factors provided in [Ref. 3] to convert the contract cost data. This function used an

```
 [0]   R←INF SETUP OC;A;B
 [1]  ⍝THIS FUNCTION USES A TWO COLUMN VECTOR, INF, AND A TWO
 [2]  ⍝COLUMN VECTOR, OC, AS INPUTS.  EACH ROW OF INF CONSISTS
 [3]  ⍝OF A TIME ENTRY AND AN INFLATION ADJUSTMENT ENTRY.  THE
 [4]  ⍝FIRST ROW OF OC CONTAINS THE NUMERICAL REPRESENTATION OF
 [5]  ⍝THE CONTRACT START DATE AND ZERO.  EACH SUBSEQUENT ROW OF
 [6]  ⍝OC CONSISTS OF THE NUMERICAL REPRESENTATION OF THE REPORT
 [7]  ⍝DATE AND ITS ASSOCIATED RAW ACWP.  THIS FUNCTION COMPUTES
 [8]  ⍝THE REPORT PERIOD EXPENDITURES, CORRECTS THEM WITH THE
 [9]  ⍝SPECIFIED INFLATION ADJUSTMENT MATRIX APN, OPN, RDT,
[10]  ⍝SCN, OR WPN, ADJUSTS THESE EXPENDITURES IN ACCORDANCE
[11]  ⍝WITH THE BASE YEAR AND THE REPORT PERIOD END DATE, AND
[12]  ⍝CUMULATIVELY SUMS THESE INFLATION ADJUSTED EXPENDITURES.
[13]  ⍝THE OUTPUT IS A TWO COLUMN MATRIX WHOSE FIRST ROW
[14]  ⍝CONSISTS OF THE CONTRACT START DATE FOLLOWED BY A ZERO,
[15]  ⍝AND WHOSE SUBSEQUENT ROWS CONSIST OF A REPORT DATE
[16]  ⍝FOLLOWED BY THE INFLATION ADJUSTED ACWPS.
[17]  ⍝
[18]  A←OC
[19]  A[;2]←0,1↓A[;2]-¯1⌽A[;2]
[20]  A[;2]←+\A[;2]×INF[(1++⌿INF[;1]∘.<A[;1]);2]
[21]  R←A
```

Figure 3.3 Inflation Adjustment Function

inflation adjustment matrix and the two column contract data matrix as inputs, computed the expenditure for each report period (the interval between successive report dates), multiplied the report period expenditures by an inflation adjustment matrix, and cumulatively summed these products. Inflation at the end of a report period was assumed to be the inflation throughout that period.

To prepare a contract's inflation adjusted cost data for linear regression, an additional transformation was required. The numerical date column was designated as the X variable and the ACWP column was designated as the Y variable. The transformations performed are shown in Equations

$$Y = \ln((dY/dt)/t) \qquad \text{(eqn 3.1)}$$

X = X**2 (eqn 3.2)

3.1 and 3.2. The transformation was accomplished by the APL function displayed in Figure 3.4. This function used the inflation adjusted ACWP values and their associated times as inputs. From this input, the report period expenditures were derived. The length of any period immediately prior to a period in which 0 dollars were spent was extended so that it equalled the sum of the lengths of both periods. This procedure prevented situations requiring the computation of the natural logarithm of zero. The period expenditures were divided by the period lengths to obtain (dY/dt). (dY/dt) was divided by the times of the end of the report periods. Finally, the times at the ends of the report periods were squared. The result was transformed contract cost data whose first column, the abscissa, was t**2, and whose second column, the ordinate, was ln((dY/dt)/t). A plot of the results after the inflation adjustment and Rayleigh trans-

```
  [0]  R←TRANS OCI;A;B
  [1]  ⍝THIS FUNCTION USES A TWO COLUMN MATRIX, OCI, AS INPUT.
  [2]  ⍝THE FIRST ROW OF OCI CONSISTS OF THE NUMERICAL
  [3]  ⍝REPRESENTATION OF THE CONTRACT START DATE FOLLOWED BY A
  [4]  ⍝ZERO.  EACH SUBSEQUENT ROW IS COMPOSED OF THE NUMERICAL
  [5]  ⍝REPRESENTATION OF THE REPORT DATE AND ITS ASSOCIATED ACWP.
  [6]  ⍝THE INPUT MATRIX IS TRANSFORMED IN ACCORDANCE WITH THE
  [7]  ⍝REQUIREMENTS OF THE RAYLEIGH MODEL.  THE OUTPUT MATRIX IS
  [8]  ⍝A TWO COLUMN MATRIX COMPOSED OF THE TRANSFORMED INPUT
  [9]  ⍝MATRIX.
 [10]  ⍝
 [11]  A←0,1↓OCI[;2]-¯1⌽OCI[;2]
 [12]  B←(A≠0)⌿OCI
 [13]  B[;1]←B[;1]-OCI[1;1]
 [14]  B[;2]←(A≠0)/A
 [15]  B[(⍴+/B);1]←OCI[(⍴+/OCI);1]-OCI[1;1]
 [16]  B[;2]←⍟B[;2]÷(B[1;1],1↓B[;1]-¯1⌽B[;1])×B[;1]
 [17]  B[;1]←B[;1]*2
 [18]  R←B
```

Figure 3.4 Rayleigh Transformation of Cost Data

formation functions were applied to Contract 1 is displayed in Figure 3.5.

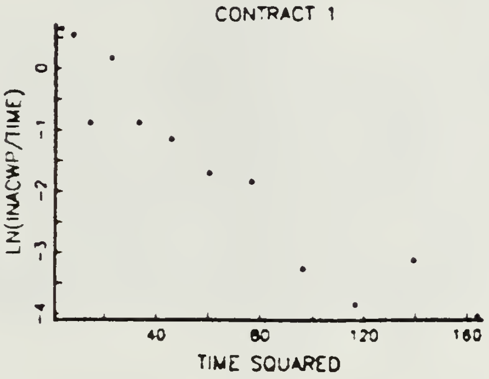

Figure 3.5 Plot of the Transformed Data of Contract 1

At this point, preparation of the contract's entire data set for linear regression was complete. While the contract was active, however, only a portion of its complete data set was available for parameter estimation, and the size of this portion would have increased as the life of the contract passed. These facts were accounted for in all subsequent APL analysis functions. The entire contract's data set was divided into subsets consisting of the data available up to each annual anniversary of the contract start date except the annual anniversary which was within one year of the last reported ACWP. In addition to operating on the contract's complete data set, the analysis functions operated on the contract's subsets. This methodology permitted comparisons of the results of the application of the Rayleigh model at yearly intervals within a contract's life.

The possibility of the cost data being unduly influenced by externalities such as strikes or political pressures was very real. To minimize the effects of the effects of these possible outliers, the least squares regression function in

```
R←LSREGRES OCI;A1;A2;A;AB;X;Y;XM;YM
⍝THIS FUNCTION USES A TWO COLUMN MATRIX, OCI, AS INPUT.
⍝THE FIRST COLUMN OF OCI IS THE REGRESSION ABSCISSA, AND
⍝THE SECOND COLUMN IS THE REGRESSION ORDINATE.  LEAST
⍝SQUARES REGRESSION IS PERFORMED.  THE OUTPUT MATRIX IS A
⍝TWO ROW MATRIX. EACH COLUMN OF THE OUTPUT MATRIX, EXCEPT
⍝THE LAST ONE, CONTAINS THE SLOPE AND INTERCEPT OF THE
⍝SUBSET OF THE INPUT DATA SET AVAILABLE AT EACH ANNUAL
⍝ANNIVERSARY OF CONTRACT START.  IF NO DATA POINTS ARE
⍝AVAILABLE, BOTH THE SLOPE AND INTERCEPT ARE SET TO ZERO.
⍝THE SLOPE AND INTERCEPT FOR AN ANNUAL ANNIVERSARY
⍝OCCURING WITHIN ONE YEAR OF THE CONTRACT'S FINAL REPORT
⍝DATE ARE EXCLUDED.  THE LAST COLUMN OF THE OUTPUT MATRIX
⍝CONTAINS THE SLOPE AND INTERCEPT OF THE COMPLETE SET OF
⍝DATA IN THE INPUT MATRIX.  A GLOBAL MATRIX, GLOBAL, IS
⍝CREATED WHICH CONTAINS INFORMATION CONCERNING WHICH
⍝DATA POINTS OF THE COMPLETE DATA SET ARE AVAILABLE AT
⍝THE VARIOUS ANNIVERSARIES.
⍝
A1←TRANS OCI
A2←(A1[;1]*.5)∘.≤1⌽(A+4),4×⍳⌊(÷4)×A←1↑|OCI[;1]-⌽OCI[;1]-4
GLOBAL←A1[;1]*0.5
AB←A2[1 2 ;]
A←1
BLOOP:→END×⍳A>ρ+⌿A2
→SKIP×⍳(+/A2[;A])<3
XM←(÷ρX)×+/(X←A2[;A]/A1[;1])
YM←(÷ρY)×+/(Y←A2[;A]/A1[;2])
AB[1;A]←((Y+.×X)-(+/Y)×XM)÷+/(X-XM)*2
AB[2;A]←YM-AB[1;A]×XM
A←A+1
→BLOOP
SKIP:AB[;A]← 0 0
A←A+1
→BLOOP
END:R←AB
```

Figure 3.6 Least Squares Linear Regression

Figure 3.6 was supplemented by the more resistant three group regression function that appears in Figure 3.7.

In three group regression, as described in [Ref. 4], the abscissa values were arranged in nondecreasing order of magnitude, and the data was divided into three groups, a left group, a middle group, and a right group. For each group, the median of the abscissas and the median of the

```
R←MED X
⍝THIS FUNCTION USES A VECTOR, X, AS INPUT.  THE MEDIAN OF
⍝X IS COMPUTED.  THE OUTPUT IS THE VALUE OF THE MEDIAN.
⍝
X←X[⍋X]
R←0.5×+/X[(⌈(⍴X)÷2),1+⌊(⍴X)÷2]
```

```
R←TGREGRES OCI;A;B;C;D;AB;G1;G2;G3;N;X;Y;XL;XM;XR;YL;YM;YR
⍝THIS FUNCTION USES A TWO COLUMN MATRIX, XY, AS INPUT.
⍝THE FIRST COLUMN OF XY IS THE REGRESSION ABSCISSA, AND
⍝THE SECOND COLUMN IS THE REGRESSION ORDINATE.  THREE
⍝GROUP REGRESSION IS PERFORMED.  THE OUTPUT MATRIX IS A
⍝TWO ROW MATRIX. EACH COLUMN OF THE OUTPUT MATRIX, EXCEPT
⍝THE LAST ONE, CONTAINS THE SLOPE AND INTERCEPT OF THE
⍝SUBSET OF THE INPUT DATA SET AVAILABLE AT EACH ANNUAL
⍝ANNIVERSARY OF CONTRACT START.  IF LESS THAN THREE DATA
⍝POINTS ARE AVAILABLE, BOTH THE SLOPE AND INTERCEPT ARE
⍝SET TO ZERO.  THE SLOPE AND INTERCEPT FOR AN ANNUAL
⍝ANNIVERSARY OCCURING WITHIN ONE YEAR OF THE CONTRACT'S
⍝FINAL REPORT DATE ARE EXCLUDED.  THE LAST COLUMN OF
⍝THE OUTPUT MATRIX CONTAINS THE SLOPE AND INTERCEPT OF THE
⍝COMPLETE SET OF DATA IN THE INPUT MATRIX.
⍝
A←TRANS OCI
B←(A[;1]*0.5)∘.≤1⌽(C+4),4×⍳⌊(÷4)×C←1↑|OCI[;1]-⌽OCI[;1]-4
AB←B[1 2 ;]
C←1
BLOOP1:→END×⍳C>⍴+⌿B
→SKIP×⍳(+/B[;C])<3
X←B[;C]/A[;1]
Y←B[;C]/A[;2]
G1←((3|⍴X)=2)+⌊(⍴X)÷3
G2←((3|⍴X)=1)+⌊(⍴X)÷3
G3←((3|⍴X)=2)+⌊(⍴X)÷3
XL←MED X[⍳G1]
XM←MED X[G1+⍳G2]
XR←MED X[G1+G2+⍳G3]
N←1
D← 50 2 ⍴0
BLOOP2:→STOP×⍳N>50
YL←MED Y[⍳G1]
YM←MED Y[G1+⍳G2]
YR←MED Y[G1+G2+⍳G3]
D[N;1]←(YR-YL)÷XR-XL
D[N;2]←(÷3)×(YL-D[N;1]×XL)+(YM-D[N;1]×XM)+(YR-D[N;1]×XR)
Y←Y-D[N;2]+D[N;1]×X
→STOP×⍳((|D[N;2])≤|0.01×D[1;2])∧((|D[N;1])≤|0.01×D[1;1])
N←N+1
→BLOOP2
STOP:AB[;C]←+⌿D
C←C+1
→BLOOP1
SKIP:AB[;C]← 0 0
C←C+1
→BLOOP1
END:R←AB
```

Figure 3.7   Three Group Linear Regression

ordinates were computed. The medians of the right and left groups were used to compute the initial value of the slope as follows:

$$A0 = (YL-YR)/(XL-XR), \qquad \text{(eqn 3.3)}$$

where

XL = median of the left group's abscissas,

YL = median of the left group's ordinates,

XR = median of the right group's abscissas, and

YR = median of the right group's ordinates.

The initial value of the intercept was computed as follows:

$$B0 = ((YL-A0*XL)+(YM-A0*XM)+(YR-A0*XR))/3, \qquad \text{(eqn 3.4)}$$

where

XM = median of the middle group's abscissas, and

YM = median of the middle group's ordinates.

The values of the slope and intercept were used to compute the values of the residuals for each data point, i.e.

$$R = Y-(B0+A0*(X-XM)). \qquad \text{(eqn 3.5)}$$

These residuals were then substituted for the ordinates in Equations 3.3 and 3.4 and used to generate a set of adjustment values, A1 and B1, to the initial slope and intercept. Thus, A0+A1 and B0+B1 were the values of the slope and intercept for the original data after two iterations through this process. A second set of residuals was computed by using A1 and B1 as the slope and intercept and repeating the substitution process. Each iteration yielded an adjustment to the initial slope and intercept. These iterations were continued until either there was a less than 1 percent change in the initial slope and intercept values, or until 50 iterations were completed. The sum of all of these iterative adjustments were added to the initial values of the slope and intercept to yield the final values. Use of two different linear regression methods allowed greater flexibility in fitting the Rayleigh distributions because a choice between two sets of estimated Rayleigh parameters could be made for each contract's data subsets.

```
R←RAYPARAM AB;A;AK
⍝THIS FUNCTION USES A TWO ROW MATRIX, AB, AS INPUT.  THE
⍝FIRST ROW CONSISTS OF A VECTOR OF SLOPES, AND THE SECOND
⍝CONSISTS OF A VECTOR OF INTERCEPTS.  THE RAYLEIGH SHAPE
⍝AND SCALE PARAMETERS ARE COMPUTED.  THE OUTPUT MATRIX IS
⍝A TWO ROW MATRIX WHOSE FIRST ROW CONSISTS OF A VECTOR OF
⍝RAYLEIGH SHAPE PARAMETERS AND WHOSE SECOND ROW CONSISTS
⍝OF A VECTOR OF RAYLEIGH SCALE PARAMETERS.
⍝
A←(AB[1;]≠0)∨AB[2;]≠0
AK←A/AB
AK[1;]←-A/AB[1;]
AK[2;]←(-÷2×A/AB[1;])×*A/AB[2;]
R←A\AK
```

Figure 3.8 Derivation of Rayleigh Parameters

The final step was to derive the Rayleigh shape and scale parameters from the slope and intercept values. The APL function shown in Figure 3.8 accomplished this task. This concludes the procedure for estimation of the Rayleigh parameters from raw contract cost data.

IV. RESULTS

A. DATA FITTING

The accuracy of the Rayleigh shape and scale parameters derived for each contract by least squares and three group regression was dependent upon the linearity of the relationship between the transformation ordinate and abscissa, and upon how well the regression methods characterized this relationship. Since the transformation did not produce perfect linearity and since the results of the two regression methods were not always in agreement, the Kolmogorov goodness-of-fit test described in [Ref. 5] was applied to the derived Rayleigh distributions and the empirical inflation adjusted cost distribution in order to identify the poorer data fits.

The hypotheses of the Kolmogorov test are as follows.

Null hypothesis:	The inflation adjusted ACWPs fit the completely specified Rayleigh distribution.
Alternate hypothesis:	The inflation adjusted ACWPs do not fit the completely specified Rayleigh distribution.

The Kolmogorov test statistic was the largest element of the vector composed of the absolute differences between the empirical distribution and the specified distribution. The desired significance level was 5 percent. Quantiles of the Kolmogorov statistic are tabulated in [Ref. 5]. The APL function in Figure 4.1 computed the Kolmogorov statistic for a specified Rayleigh distribution and an empirical distribution. For each contract, the Kolmogorov test was performed twice; the first test was applied to the empirical distribution and the Rayleigh distribution as estimated by least

```
R←AAKK KOLMOV OC;A;B;N1;N2;FT;FE
⍝THIS FUNCTION USES A TWO ROW MATRIX, AAKK, AND A TWO
⍝COLUMN MATRIX, OC, AS INPUTS.  THE FIRST AND THIRD ROWS
⍝OF AAKK CONTAIN VECTORS OF RAYLEIGH SHAPE AND SCALE
⍝PARAMETERS, RESPECTIVELY, DERIVED BY LEAST SQUARES
⍝REGRESSION AND NOT REJECTED BY THE KOLMOGOROV TEST:  THE
⍝SECOND AND FOURTH ROWS CONTAIN VECTORS OF RAYLEIGH SHAPE
⍝AND SCALE PARAMETERS, RESPECTIVELY, DERIVED BY THREE
⍝GROUP REGRESSION AND NOT REJECTED BY THE KOLMOGOROV TEST.
⍝THE FIRST ROW OF OC IS THE NUMERICAL REPRESENTATION OF
⍝THE CONTRACT START DATE FOLLOWED BY A ZERO.  EACH SUBSE-
⍝QUENT ROW IS COMPOSED OF THE NUMERICAL REPRESENTATION
⍝OF THE REPORT DATE AND ITS ASSOCATED INFLATION ADJUSTED
⍝ACWP.  THIS FUNCTION SELECTS THE APPRORIATE KOLMOGOROV
⍝.95 QUANTILE TEST STATISTIC.  FOR EACH REGRESSION METHOD,
⍝THE KOLMOGOROV STATISTIC IS COMPUTED, THE SETS OF
⍝PARAMETERS NOT REJECTED ARE INDICATED, AND THE VALUES OF
⍝THE ACCEPTED PARAMETERS ARE LISTED.  THE OUTPUT IS A NINE
⍝ROW MATRIX WHOSE FIRST ROW IS A VECTOR OF KOLMOGOROV TEST
⍝STATISTICS, AND WHOSE SECOND AND THIRD ROWS ARE VECTORS
⍝OF THE KOLMOGOROV STATISTICS FOR LEAST SQUARES AND THREE
⍝GROUP REGRESSION, RESPECTIVELY.  THE FOURTH AND FIFTH
⍝ROWS ARE VECTORS OF INDICATOR VALUES FOR LEAST SQUARES
⍝AND THREE GROUP REGRESSION, RESPECTIVELY, WHERE 1 DENOTES
⍝PASSING OF THE KOLMOGOROV TEST AND 0 DENOTES FAILURE TO
⍝PASS THE KOLMOGOROV TEST.  THE SIXTH AND SEVENTH ROWS
⍝CONTAIN THE VECTORS, DERIVED BY LEAST SQUARES REGRESSION,
⍝OF THE RAYLEIGH SHAPE AND SCALE PARAMETERS, RESPECTIVELY.
⍝THE EIGHTH AND NINTH ROWS CONTAIN VECTORS, DERIVED BY
⍝THREE GROUP REGRESSION, OF THE RAYLEIGH SHAPE AND SCALE
⍝PARAMETERS, RESPECTIVELY.  IN ROWS SIX THROUGH NINE,
⍝ZEROES DENOTE FAILURE TO PASS THE KOLMOGOROV TEST.
⍝
A←3×((⍳9)=⍳9)∘.×AAKK[1;]=AAKK[1;]
B←+⌿GLOBAL∘.≤1⌽(N1+4),4×⍳⌊(÷4)×N1←1↑|OC[;1]-⌽OC[;1]-4
A[1;]←,((B≠0)∧B≤40)⍀KSTAT[((B≠0)∧B≤40)/B;]
A[1;]←A[1;]+1.36×(B>40)÷B*0.5
N1←1
BLOOP1:→ELOOP1×⍳N1>2
N2←1
BLOOP2:→ELOOP2×⍳N2>⍴B
→SKIP1×⍳(+/AAKK[(N1=2)+ 1 3 ;N2]≠0)=0
FE←(FE≤GLOBAL[(B[N2])])/(FE←OC[;1]-OC[1;1])*2
FT←1-*-FE×AAKK[N1;N2]
FE←(÷B[N2])×⍳B[N2]
A[N1+1;N2]←⌈/|FT-(((⍴FT)-⍴FE)⍴0),FE
→SKIP2
SKIP1:A[N1+1;N2]←2
SKIP2:N2←N2+1
→BLOOP2
ELOOP2:N1←N1+1
→BLOOP1
ELOOP1:A[4 5 ;]←A[2 3 ;]<A[1 1 ;]
A[6 7 ;]←A[4 4 ;]×AAKK[1 3 ;]
A[8 9 ;]←A[5 5 ;]×AAKK[2 4 ;]
R←A
```

Figure 4.1   Kolmogorov Test

squares regression and the second test was applied to the empirical distribution and the the Rayleigh distribution as estimated by three group regression. The results of the Kolmogorov tests are listed in Table 2. The entries in each of the first ten columns show the results of the application of the Kolmogorov test to each contract's data subsets. The rightmost column shows the results of the application of the Kolmogorov test to each contract's complete data set. For each pair of rows associated with each contract, the first row displays the results when least squares regression was used to estimate the Rayleigh parameters, and the second row shows the results when three group regression was used.

For each contract, except Contract 21, the Rayleigh parameters estimated for the complete data set by at least one of the regression methods passed the Kolmogorov test. In 8 contracts, Contracts 1, 7, 9, 11, 13, 16, 17, and 21, every contract subset passed the Kolmogorov test as did the complete data set. All contract subsets in Contracts 2, 6, 18, and 20, however, failed the Kolmogorov test despite the the fact that their complete data sets passed it. The remaining 9 contracts exhibited mixtures of passing and failure of the Kolmogorov tests in their contract subsets. Since the empirical distribution changed as subset size was increased, failure of the Kolmogrov test early in a contract's life did not preclude passing of the test later on in the cost stream. This table has shown that the Rayleigh model, when applied to the complete contract data set can pass the Kolmogorov test. The proper way to use the results of this test would be to not use the Rayleigh model whenever the Rayleigh distribution derived by either regression method fails the Kolmogorov test. Thus, the applicability of the Rayleigh model was rejected for 7 contracts, Contracts 2, 5, 6, 8, 18, 20, and 21, based on the failures of the Kolmogorov tests in their contract subsets.

TABLE 2

Kolmogorov Test Results

Contract Number	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Contract End
1	A	A	*	*	*	*	*	*	*	*	A
	A	A	*	*	*	*	*	*	*	*	A
2	R	R	R	*	*	*	*	*	*	*	A
	R	R	R	*	*	*	*	*	*	*	A
3	A	R	R	A	A	*	*	*	*	*	A
	A	R	R	R	A	*	*	*	*	*	A
4	R	A	A	A	*	*	*	*	*	*	A
	R	R	A	A	*	*	*	*	*	*	A
5	R	R	R	R	R	*	*	*	*	*	A
	R	R	R	R	R	*	*	*	*	*	R
6	R	R	R	R	*	*	*	*	*	*	A
	R	R	R	R	*	*	*	*	*	*	A
7	A	A	A	A	*	*	*	*	*	*	A
	A	A	A	A	*	*	*	*	*	*	A
8	R	R	*	*	*	*	*	*	*	*	A
	R	R	*	*	*	*	*	*	*	*	R
9	A	A	A	A	*	*	*	*	*	*	A
	A	A	A	A	*	*	*	*	*	*	A
10	A	A	A	*	*	*	*	*	*	*	A
	A	R	A	*	*	*	*	*	*	*	A
11	A	A	A	*	*	*	*	*	*	*	A
	A	A	A	*	*	*	*	*	*	*	A
12	A	R	R	*	*	*	*	*	*	*	A
	A	R	R	*	*	*	*	*	*	*	A
13	A	A	*	*	*	*	*	*	*	*	A
	A	A	*	*	*	*	*	*	*	*	A
14	R	A	A	A	*	*	*	*	*	*	A
	R	A	A	A	*	*	*	*	*	*	A
15	R	R	R	R	R	A	A	*	*	*	A
	R	R	R	R	R	A	R	*	*	*	A
16	A	A	*	*	*	*	*	*	*	*	A
	A	A	*	*	*	*	*	*	*	*	A
17	A	A	*	*	*	*	*	*	*	*	A
	A	A	*	*	*	*	*	*	*	*	A
18	R	R	R	*	*	*	*	*	*	*	A
	R	R	R	*	*	*	*	*	*	*	A
19	R	R	R	R	R	R	R	A	*	*	A
	R	R	R	R	R	R	A	A	*	*	A
20	R	R	R	*	*	*	*	*	*	*	A
	R	R	R	*	*	*	*	*	*	*	A
21	R	R	*	*	*	*	*	*	*	*	R
	R	R	*	*	*	*	*	*	*	*	R

R denotes rejection of the null hypothesis in the Kolmogorov test.
A denotes acceptance of the null hypothesis in the Kolmogorov test.
* denotes within 1 year of the last reported ACWP.

For each contract, the first row pertains to least squares regression, and the second to three group regression.

The Rayleigh model, based on the results of the Kolmogorov test, has proven applicable to modelling contract cost streams in 14 of the 21 contracts examined. The question of whether or not the results for these 14 contracts show any predictive merit needs to be addressed.

B. PREDICTIVE CAPABILITY OF THE RAYLEIGH MODEL

In order to have the best chance of exhibiting usefulness in forecasting, the set of Rayleigh variates with the best fit to the inflation adjusted ACWPs should be selected. The Kolmogorov statistic is the absolute value of the greatest probability difference between a completely specified cumulative distribution and an empirical cumulative distribution. It is supposed to be compared to tabulated values of quantiles of the Kolmogorov test statistic to determine whether or not its value lies in the rejection region. In the case where both regression methods yielded Rayleigh distributions that passed the Kolmogorov test, it was improper to draw conclusions about the quality of their fits to the empirical distribution based on the magnitude of the Kolmogorov statistic. Another measure was required.

In least squares linear regression, the residual is

$$R = Y-YBAR, \qquad \text{(eqn 4.1)}$$

and the error is

$$E = YHAT-Y. \qquad \text{(eqn 4.2)}$$

Additionally,

SST = SSR + SSE, (eqn 4.3)

where

SST = Total Sum of Squares,
SSR = Residual Sum of Squares, and
SSE = Error Sum of Squares.

Finally, the correlation for least squares regression is

CORRELATION = (1-(SSE/(SSR+SSE)))**.5. (eqn 4.4)

The values of SSR and SSE are computed based on a regression equation that minimizes SSE.

In the case of an ideal forecast, the Rayleigh variates would be equal to the corresponding inflation adjusted

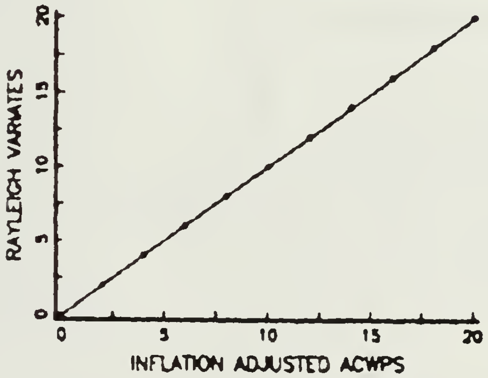

Figure 4.2 Ideal Relationship Between ACWPs and Rayleigh Variates.

ACWPs, and a plot of the ACWPs and the variates would look like the plot in Figure 4.2, where all points lie on the line Y = X. A measure that quantifies how well each set of

Rayleigh variates, Y, and the inflation adjusted ACWPs, X, fit the line Y = X would allow the Rayleigh variates with the best fit to be selected. Performing least squares regression on the empirical data and the corresponding Rayleigh variates would yield the correlation, a measure of the quality of fit. However, the correlation would be a measure of the quality of the fit to a line obtained by least squares linear regression and not a measure of the quality of fit to the line Y = X. As shown in Equation 4.4, correlation is computed based on the fraction of the total sum of squares that is due to the squared error about a line derived by least squares regression. The ACWPs are the Xs and the Rayleigh variates are the Ys. If the fit was perfect, the Rayleigh deviates would equal the ACWPs; therefore, the ideal line is:

$$YHAT = X. \qquad \text{(eqn 4.5)}$$

Consequently, the residuals are

$$R = YHAT-YBAR = X-YBAR, \qquad \text{(eqn 4.6)}$$

and the errors are

$$E = YHAT-Y = X-Y. \qquad \text{(eqn 4.7)}$$

The fraction of the total sum of squares, SSR+SSE, that is due to the squared errors about the ideal line YHAT = X can be computed. This measure is called the pseudocorrelation (PC) and is defined as follows:

$$PC = (1-(SSR/(SSR+SSE)))**.5. \qquad \text{(eqn 4.8)}$$

The pseudocorrelation can range in value from 0 to 1. An ideal fit between the inflation adjusted ACWPs and the Rayleigh variates would yield a pseudocorrelation equal to 1.

The magnitude of the pseudocorrelation was used to determine which set of parameters, estimated by the two regression methods, characterized the Rayleigh distribution whose variates best fitted each contract's subsets of inflation adjusted ACWPs. The regression method with the highest psuedocorrelation had the best fit. The better of the two methods is indicated in Table 3.

TABLE 3

Regression Method Providing the Best Fit

Contract Number	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
1	LS	TG	*	*	*	*	*	*	*	*
2	REJECTED									
3	TG	TG	TG	LS	LS	*	*	*	*	*
4	TG	LS	TG	TG	*	*	*	*	*	*
5	REJECTED									
6	REJECTED									
7	TG	TG	LS	LS	*	*	*	*	*	*
8	REJECTED									
9	TG	LS	LS	TG	*	*	*	*	*	*
10	TG	LS	LS	*	*	*	*	*	*	*
11	TG	LS	LS	*	*	*	*	*	*	*
12	TG	TG	TG	*	*	*	*	*	*	*
13	LS	TG	LS	*	*	*	*	*	*	*
14	TG	TG	TG	TG	*	*	*	*	*	*
15	TG	TG	TG	TG	TG	TG	LS	*	*	*
16	TG	LS	*	*	*	*	*	*	*	*
17	TG	TG	*	*	*	*	*	*	*	*
18	REJECTED									
19	TG	TG	TG	TG	TG	TG	TG	TG	*	*
20	REJECTED									
21	REJECTED									

LS denotes least squares regression.
TG denotes three group regression.
* denotes within 1 year of the last reported ACWP.

If the model has any predictive attributes, higher qualities of fit for a contract's subsets should be associated with a higher quality of fit for the contract's complete data set. This hypothesis was tested using Spearman's rank correlation coefficient described in [Ref. 5] as a test statistic. The formal statements of the hypotheses are as follows:

Null hypothesis:	The contract subset pseudocorrelations are independent of the contract end pseudocorrelations;
Alternate hypothesis:	There is a tendency for the larger values of the contract subset pseudocorrelations to be paired with the larger values of the contract end pseudocorrelations.

```
R←RANK Y;A;B;C
⍝THIS FUNCTION USES A VECTOR, Y, AS INPUT.  THE ELEMENTS
⍝OF Y ARE RANKED IN DECREASING ORDER OF MAGNITUDE, THE
⍝LOWEST RANK BEING ASSIGNED TO THE LARGEST ELEMENT.  THE
⍝RANKING METHODOLOGY IS IN ACCORDANCE WITH SECTION 5.4
⍝OF REF. 5.
⍝
A←Y[B←(+/(Y∘.<Y)+(Y∘.=Y)∧((⍳⍴Y)∘.≥⍳⍴Y))⍳⍳⍴Y]
C←((⍳⍴Y)+.×(A∘.=A))÷+/A∘.=A
R←C[B⍳⍳⍴Y]

R←X SPEARRO Y;A1;A2;B;C
⍝THIS FUNCTION USES TWO VECTORS, X AND Y, OF EQUAL LENGTH
⍝AS INPUT.  THE LENGTHS OF THE INPUT VECTORS MUST BE
⍝GREATER THAN THREE AND LESS THAN THIRTY-ONE.  THE
⍝ELEMENTS WITHIN EACH INPUT VECTOR ARE RANKED
⍝AND  SPEARMAN'S RANK CORRELATION COEFFICIENT IS
⍝COMPUTED.  THE OUTPUT OF THIS FUNCTION IS A TWO ELEMENT
⍝VECTOR WHOSE FIRST ELEMENT IS THE .95 QUANTILE OF THE
⍝SPEARMAN TEST STATISTIC FOLLOWED BY THE RANK CORRELATION
⍝COEFFICIENT.
⍝
A1←RANK X
A2←RANK Y
B←(+/A1×A2)-C←((⍴A1)×(((⍴A1)+1)÷2)*2)
B←B÷((((+/A1*2)-C)*0.5)×(((+/A2*2)-C)*0.5)
R←B,SSTAT[((⍴X)=0)+⍴X;1]
```

Figure 4.3 Spearman's Rho

The APL functions in Figure 4.3 computed Spearman's coefficient, and the results of the test are displayed in Table 4.

TABLE 4

Pseudocorrelation Ranks and Spearman's Test Results

Contract Number	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
1	5 6	7 6	**	**	**	**	**	**	**	**
2	REJECTED									
3	2 1	R	R	3 2	**	**	**	**	**	**
4	**	1 1	1 1	1 1	1 1	**	**	**	**	**
5	REJECTED									
6	REJECTED									
7	1 4	3 4	5 4	4 4	**	**	**	**	**	**
8	REJECTED									
9	9 3	6 3	4 3	2 3	**	**	**	**	**	**
10	3 2	4 2	2 2	**	**	**	**	**	**	**
11	4 7	2 7	3 5	**	**	**	**	**	**	**
12	7 8	**	**	**	**	**	**	**	**	**
13	8 9	5 9	**	**	**	**	**	**	**	**
14	R	9 8	6 6	5 5	**	**	**	**	**	**
15	R	R	R	R	R	1 1	1 2	**	**	**
16	6 5	8 5	**	**	**	**	**	**	**	**
17	10 10	10 10	**	**	**	**	**	**	**	**
18	REJECTED									
19	R	R	R	R	R	R	2 1	1 1	**	**
20	REJECTED									
21	REJECTED									
RHOHAT	.636	.600	.829	.900						
RHO	.552	.552	.771	.800						

For each year, the left column is the rank of the contract subset pseudocorrelation, and the right column is the rank of the contract end pseudocorrelation.

R denotes rejection of the null hypothesis in the Kolmogorov test for a particular subset.

** denotes within one year of the last reported ACWP.

The null hypothesis was tested at the 5 percent level, and quantiles of Spearman's rank correlation coefficient are tabulated in [Ref. 5]. RHOHAT in Table 4 is the value of Spearman's statistic computed for each pair of columns under which it appears. RHO is the value of the test statistic. In each of the 4 cases where there were enough ranks available to apply the test, the null hypothesis was rejected. Therefore, the higher subset pseudocorrelations tended to be associated with higher pseudocorrelations for the complete data set. From this observation, it can be inferred that the better the derived Rayleigh variates fit the inflation adjusted ACWPs during a contract's life, the better the contract will fit the derived Rayleigh parameters at its completion.

Convergence of a contract's subset Rayleigh shape and scale parameters to the values for the complete data set would be an indication of the presence of predictive capability in the Rayleigh model. The convergence information for each contract is displayed in Table 5 through the use of state vectors. The 4 possible states are defined as follows:

0 Null hypothesis is rejected./Both a and K are not within 5% of their final values;

1 Null hypothesis is rejected./Both a and K are within 5% of their final values;

2 Null hypothesis is accepted./Both a and K are not within 5% of their final values; and

3 Null hypothesis is accepted./Both a and K are within 5% of their final values.

The presence of 3s in a contract's state vector is the indicator of convergence of both Rayleigh parameters to their final values in Table 5. Only contract 19 had 3s in its state vector. This contract had the highest end pseudocorrelation of the 14 accepted contracts, and exhibited convergence in years 8 and 9. During a contract's life, however, the final values of the Rayleigh parameters are not available, therefore, comparisons cannot be made to them. It is possible, though, to make comparisons between the

TABLE 5

State Vectors for Convergence to Final Values

Contract Number	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
1	2	2	*	*	*	*	*	*	*	*
2	REJECTED									
3	2	0	0	2	2	*	*	*	*	*
4	0	2	2	2	*	*	*	*	*	*
5	REJECTED									
6	REJECTED									
7	2	2	2	2	*	*	*	*	*	*
8	REJECTED									
9	2	2	2	2	*	*	*	*	*	*
10	2	2	2	*	*	*	*	*	*	*
11	2	2	2	*	*	*	*	*	*	*
12	2	0	0	*	*	*	*	*	*	*
13	2	2	*	*	*	*	*	*	*	*
14	0	2	2	2	*	*	*	*	*	*
15	0	0	0	0	0	2	2	*	*	*
16	2	2	*	*	*	*	*	*	*	*
17	2	2	*	*	*	*	*	*	*	*
18	REJECTED									
19	0	0	0	0	0	0	3	3	*	*
20	REJECTED									
21	REJECTED									

* denotes within 1 year of the last reported ACWP.

previous annual anniversary's pair of Rayleigh parameters and the present anniversary's pair. These comparisons provide the basis for the state vectors displayed in Table 6. The states are defined as follows:

0 Null hypothesis is rejected./Previous a,K pair is not within 5% of the present anniversary values;

1 Null hypothesis is rejected./Previous a,K pair is within 5% of the present anniversary values;

2 Null hypothesis is accepted./Previous a,K pair is not within 5% of the presnet anniversary values; and

3 Null hypothesis is accepted./Previous a,K pair is within 5% of the present anniversary values.

It is apparent from Tables 5 and 6 that for this set of contracts, the Rayleigh parameters estimated early in a contract's life were not useful for predicting costs. Only in Contract 19 was convergence exhibited, and it was not until 8 years after contract start and less than 2 years prior to the last reported ACWP. The predictive capability of the Rayleigh model for this set of 14 contracts was almost nonexistent. However, the result in Contract 19, the results of the application of the Kolmogorov test, and the encouraging behavior of the pseudocorrelation indicate that analysis of a larger number of contracts might lead to more positive results as far as predictive capability is concerned.

TABLE 6

State Vectors for Convergence of Adjacent Values

Contract Number	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10
1	2	2	*	*	*	*	*	*	*	*
2	REJECTED									
3	2	0	0	2	2	*	*	*	*	*
4	0	2	2	2	*	*	*	*	*	*
5	REJECTED									
6	REJECTED									
7	2	2	2	2	*	*	*	*	*	*
8	REJECTED									
9	2	2	2	2	*	*	*	*	*	*
10	2	2	2	*	*	*	*	*	*	*
11	2	2	2	*	*	*	*	*	*	*
12	2	0	0	*	*	*	*	*	*	*
13	2	2	*	*	*	*	*	*	*	*
14	0	2	2	2	*	*	*	*	*	*
15	0	0	0	0	0	2	2	*	*	*
16	2	2	*	*	*	*	*	*	*	*
17	2	2	*	*	*	*	*	*	*	*
18	REJECTED									
19	0	0	0	0	0	0	2	3	*	*
20	REJECTED									
21	REJECTED									

* denotes within 1 year of last reported ACWP.

The procedure used in the progression from raw historical contract data to the state vectors can be summarized as follows:

1) Adjust the raw ACWPs to constant year dollars;
2) Transform the data in accordance with the requirements of the Rayleigh model;
3) Perform least squares and three group linear regression to estimate the Rayleigh parameters;
4) Apply the Kolmogorov test, first to the empirical distribution and the Rayleigh distribution derived by least squares regression, then to the empirical distribution and the Rayleigh distribution derived by three group regression;
5) If both Rayleigh distributions pass the Kolmogorov test, select the one whose variates best fit the inflation adjusted ACWPs based on the highest pseudocorrelation; and
6) Derive the state vectors.

This procedure is implemented in a function called PROCESS listed in Appendix B. This function generates a matrix that displays the results at 11 points in the application of the Rayleigh model to the raw contract data. In Appendix C, the information summaries for all 21 of the contracts examined are displayed.

V. CONCLUSIONS

The results of the analysis of the 21 contracts revealed that parameters of the Rayleigh distribution can be estimated such that they fit historical contract data. However, there was almost no success in using the model in a predictive role. There is a chance that the poor predictive results could have been due to the small size of the number of contracts examined. This possibility is justification for continuing the investigation of the predictive capability of the Rayleigh model using the PROCESS algorithm in conjunction with other historical contract data.

APPENDIX A

CONTRACT DATA

Contract 1
Captor Mine

Date	ACWP
10.87	.0
12.61	8.1
13.61	14.7
14.62	16.9
15.60	24.6
16.61	28.3
17.61	31.6
18.62	33.8
19.60	35.9
20.67	36.6
21.66	37.0
22.66	37.9
23.67	38.3

Contract 2
CH-53

Date	ACWP
18.46	.0
21.66	4.7
22.66	7.9
23.67	12.6
24.67	19.8
25.66	27.8
26.66	42.8
27.67	56.6
28.67	74.9
29.66	90.9
30.66	108.5
31.66	123.3
32.33	130.6
33.33	139.5
34.33	152.9
35.33	157.4
36.34	161.9
37.66	169.2

Contract 3
F-18

Date	ACWP
10.24	.0
11.27	20.6
12.61	49.5
13.93	97.0
14.62	123.4
15.60	185.9
16.61	260.3
17.61	412.2
18.62	515.6
19.27	597.3
19.60	639.1
19.95	674.8
20.61	748.0
21.61	850.5
22.62	933.4
23.44	1011.3
24.61	1071.2
25.66	1150.7
26.66	1207.9
27.67	1271.1
28.00	1294.1
28.67	1340.9
29.66	1396.1
30.66	1458.2
31.67	1502.0
32.00	1516.7
32.66	1547.5
33.66	1582.3
34.66	1616.8
35.67	1640.2
37.66	1670.1

Contract 4
F-18

Date	ACWP
9.57	.0
10.27	4.0
10.93	9.5
11.95	23.3
12.95	38.5
13.27	45.6
13.93	52.6
14.62	74.7
15.60	97.3
16.61	111.3
17.61	127.7
18.62	144.9
19.60	167.9
20.61	187.9
21.50	211.6
22.62	230.3
23.60	261.7
24.61	279.1
25.68	288.6
26.68	296.5
27.68	303.4
28.67	310.9
29.36	315.0
30.66	321.7
31.66	323.7
32.36	325.9
32.97	329.9

Contract 5
FFG-7

Date	ACWP
14.46	.0
16.27	.0
16.95	1.4
17.93	3.8
18.93	7.0
19.96	11.2
20.95	15.9
22.00	22.4
22.93	33.8
23.95	38.6
24.92	50.5
25.91	62.5
26.99	78.0
27.99	88.9
28.98	93.9
29.97	103.7
30.98	118.5
31.98	133.6
32.97	146.8
33.96	157.7
35.97	170.9
36.96	172.2
37.95	173.3
39.00	173.3

Contract 6
FFG-7

Date	ACWP
10.64	.0
14.93	6.7
16.27	11.1
16.95	19.4
17.93	30.9
18.93	42.6
19.95	61.1
20.95	73.6
22.00	87.9
22.93	100.9
23.95	113.4
24.92	118.3
25.91	137.2
26.00	137.2
26.99	149.9
27.99	161.0
28.98	165.0
29.97	169.7
30.98	172.9

Contract 7
FFG-7

Date	ACWP
18.06	.0
20.95	15.7
21.00	16.6
22.00	22.0
23.00	25.0
25.00	38.3
25.99	44.3
26.99	47.3
28.00	53.0
29.00	58.7
30.00	65.4
31.00	73.1
32.00	82.6
33.00	93.6
33.99	103.9
34.99	110.2
36.00	117.5
37.00	118.0
38.00	118.6
39.00	119.8

Contract 8
Harpoon

Date	ACWP
9.38	.0
10.62	2.0
10.93	3.0
11.27	4.5
11.60	8.8
11.95	11.5
12.27	12.8
12.61	17.0
12.95	20.4
13.27	25.5
13.61	30.9
14.62	45.5
15.60	61.6
16.61	74.8
17.61	94.2
18.62	99.6
19.60	107.0
20.61	114.2
22.63	119.1
24.00	123.2

Contract 9
Lamps III

Date	ACWP
14.06	.0
15.60	14.6
16.61	26.3
17.61	42.3
18.62	61.2
19.60	76.8
20.61	91.6
21.66	105.2
22.62	121.6
23.67	136.6
24.67	151.4
25.66	163.6
26.65	172.6
27.67	184.3
28.67	195.2
29.66	208.2
30.66	219.7
30.99	230.7
32.33	236.7
33.33	243.0
34.33	248.0
35.33	251.4
36.00	253.2

Contract 10
Lamps III

Date	ACWP
18.66	.0
19.60	8.4
20.61	12.3
21.61	18.1
22.51	25.0
23.67	32.5
24.67	42.4
25.66	52.4
26.65	63.0
27.67	76.4
28.67	85.4
29.66	93.7
30.66	99.8
31.67	105.5
32.33	108.5
33.33	111.4
34.33	114.6
35.33	117.3
36.00	119.6

Contract 11
Lamps III

Date	ACWP
18.66	.0
19.60	2.6
20.61	5.3
21.61	7.8
23.67	14.0
24.67	17.4
25.66	20.5
26.65	24.7
27.67	26.5
28.67	27.8
29.66	29.2
30.66	30.7
31.66	32.4
32.33	32.8
33.33	34.1
34.33	35.0
35.35	37.1
35.97	38.0

Contract 12
PHM

Date	ACWP
17.33	.0
18.62	4.7
19.60	8.3
20.61	14.8
21.66	23.9
22.51	37.1
23.60	55.3
24.61	78.9
25.57	105.1
26.65	133.6
27.65	159.7
28.64	182.1
29.63	202.3
30.63	218.9
31.64	235.0
32.33	245.1
33.32	258.3
34.31	269.4
35.32	279.8
36.32	287.9

Contract 13
TACTAS

Date	ACWP
25.11	.0
26.68	4.8
27.68	9.8
28.67	14.2
29.66	18.9
30.66	22.7
31.66	26.0
32.33	27.8
33.65	30.7
34.66	32.8
35.35	34.1
36.35	36.1
37.64	37.5
38.41	38.3
39.42	39.1

Contract 14
Tomahawk

Date	ACWP
14.06	.0
17.61	51.1
18.28	63.5
19.27	86.2
20.34	106.6
21.34	128.5
22.34	142.0
23.33	159.0
24.34	173.9
25.34	190.6
26.34	206.3
27.33	219.7
28.29	230.1
29.28	245.3
30.28	255.5
31.29	267.8
32.28	279.3
33.27	288.7
34.28	296.5
35.27	302.7
35.97	307.2

Contract 15
Tomahawk

Date	ACWP
4.38	.0
17.61	24.0
18.28	27.8
19.27	29.8
20.34	34.8
21.34	39.1
22.34	42.0
23.33	45.2
24.34	48.5
25.33	52.3
26.34	54.7
27.33	57.2
28.34	59.5
29.34	62.1
30.34	65.0
31.33	67.2
32.33	69.5
33.33	71.5
34.33	73.9
35.33	76.3
36.00	77.6
37.34	80.2
38.34	82.3

Contract 16
Tomahawk

Date	ACWP
16.54	.0
17.61	7.9
18.28	11.5
19.27	14.4
20.34	18.2
21.34	22.0
22.34	28.8
23.33	32.6
24.34	37.1
25.34	40.7
26.34	43.4
27.33	46.0
28.34	46.2
29.34	46.4

Contract 17
Tomahawk

Date	ACWP
17.77	.0
19.27	31.6
20.34	38.0
21.34	46.4
22.34	54.2
23.33	62.0
24.34	71.2
25.34	78.4
26.34	83.9
27.33	89.3
28.34	89.7
29.34	89.9
30.34	91.3
31.33	93.1

Contract 18
Tomahawk

Date	ACWP
22.63	.0
28.34	12.6
29.34	19.5
30.34	26.3
31.33	37.5
32.33	46.5
33.33	55.6
34.33	62.1
35.33	79.8
36.00	83.1
37.34	90.2
38.34	95.2
39.33	97.6
40.34	99.2

Contract 19
Trident I

Date	ACWP
4.27	.0
6.93	13.0
7.95	27.6
8.95	44.7
9.93	64.5
10.93	105.1
11.95	145.8
12.95	189.0
15.95	387.1
16.95	460.0
17.93	526.6
18.93	574.8
20.01	639.3
21.00	700.5
21.91	763.4
23.15	831.3
24.00	890.1
24.99	942.8
25.90	990.3
26.98	1064.9
27.98	1125.5
28.97	1190.2
29.88	1244.4
30.97	1309.3
31.97	1370.5
32.96	1431.0
33.95	1490.1
34.96	1547.2
35.96	1599.8
36.95	1657.5
37.93	1701.4
39.02	1744.0
40.02	1775.9
41.01	1794.3
41.92	1803.8

Contract 20
CG-47

Date	ACWP
20.91	.0
22.00	.0
22.83	3.8
23.67	8.6
25.00	20.4
26.89	50.9
27.89	73.0
28.20	82.7
29.87	143.3
31.57	197.9
32.33	231.6
33.55	255.6
34.33	276.0
35.33	296.5
36.34	312.3
37.34	325.8
38.34	337.9

Contract 21
AS-39, 40

Date	ACWP
5.55	.0
5.93	.1
6.28	.2
6.62	.4
7.27	1.2
7.60	1.8
7.95	2.5
8.27	4.1
8.61	5.9
8.95	8.1
9.27	10.1
9.61	11.6
9.93	13.5
10.27	17.7
10.62	22.8
10.93	28.2
11.27	33.9
11.60	39.2
11.95	44.3
12.33	53.2
12.61	59.9
12.95	67.8
13.27	77.6
13.61	87.1
13.93	96.6
14.93	125.5
15.27	136.3
15.60	144.6
15.95	152.5
16.27	164.4
16.61	172.3
16.95	179.6
17.27	189.9
17.61	195.9
17.93	202.5
18.28	209.8
18.62	214.8
18.93	220.4
19.27	226.9

APPENDIX B

RAYLEIGH MODEL PROCESSING FUNCTIONS

```
  [0]  R←INF PROCESS OC;OCI;A;B;AAKK;KV6789;PC67
  [1]  ⍝THIS FUNCTION USES A TWO COLUMN MATRIX, INF, AND A TWO
  [2]  ⍝COLUMN MATRIX, OC, AS INPUTS.  EACH ROW OF INF CONSISTS
  [3]  ⍝OF A TIME AND AN INFLATION ADJUSTMENT FACTOR.
  [4]  ⍝THE FIRST ROW OF OC CONSISTS OF THE NUMERICAL
  [5]  ⍝REPRESENTATION OF THE CONTRACT DATE FOLLOWED BY ZERO.
  [6]  ⍝EACH SUBSEQUENT ROW IS COMPOSED OF THE NUMERICAL
  [7]  ⍝REPRESENTATION OF THE REPORT DATE AND ITS ASSOCIATED RAW
  [8]  ⍝ACWP.  THE CONTRACT IS PROCESSED THROUGH THE RAYLEIGH
  [9]  ⍝MODEL.  THE OUTPUT OF THIS FUNCTION IS A 24 ROW MATRIX
 [10]  ⍝OF INFORMATION CONCERNING THE PROCESSING OF THE CONTRACT
 [11]  ⍝BY THE RAYLEIGH MODEL.  EACH COLUMN OF THIS OUTPUT
 [12]  ⍝MATRIX, EXCEPT THE LAST ONE, CONTAINS 24 ENTRIES WHICH
 [13]  ⍝SUMMARIZE THE PROCESSING OF THE SUBSET OF THE INPUT DATA
 [14]  ⍝AVAILABLE AT EACH ANNUAL ANNIVERSARY OF CONTRACT START.
 [15]  ⍝THE INFORMATION SUMMARY ON AN ANNUAL ANNIVERSARY WITHIN
 [16]  ⍝ONE YEAR OF THE FINAL REPORT DATE IS EXCLUDED.  THE LAST
 [17]  ⍝COLUMN OF THE OUTPUT MATRIX IS AN INFORMATION SUMMARY
 [18]  ⍝ON THE COMPLETE SET OF DATA IN THE INPUT MATRIX.
 [19]  ⍝
 [20]  OCI←INF SETUP OC
 [21]  A←B←RAYPARAM LSREGRES OCI
 [22]  A←(⍳24)∘.×B[1;]
 [23]  A[1 3 ;]←B
 [24]  A[2 4 ;]←RAYPARAM TGREGRES OCI
 [25]  AAKK←A[1 2 3 4 ;]
 [26]  'EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL'
 [27]  'ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST'
 [28]  'COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE'
 [29]  'DATA SET.  ZEROES DENOTE REJECTION OF THE NULL'
 [30]  'HYPOTHESIS IN THE KOLMOGOROV TEST.'
 [31]  SPACE1
 [32]  'THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST'
 [33]  'SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.'
 [34]  7 4 ⍕A[1 2 ;]
 [35]  SPACE1
 [36]  'THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST'
 [37]  'SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.'
 [38]  8 1 ⍕A[3 4 ;]
 [39]  SPACE1
 [40]  A[4+⍳9;]←AAKK KOLMOV OCI
 [41]  KV6789←A[10 11 12 13 ;]
 [42]  'THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.'
 [43]  A[5;]
 [44]  SPACE1
 [45]  'THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST'
 [46]  'SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.'
 [47]  7 4 ⍕A[6 7 ;]
 [48]  SPACE1
 [49]  'THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING'
 [50]  'ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES'
 [51]  'AND THREE GROUP REGRESSION, RESPECTIVELY.'
 [52]  A[8 9 ;]
 [53]  SPACE1
 [54]  'THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAME-'
 [55]  'TERS, RESPECTIVELY, FOR LEAST SQUARES REGRESSION.'
 [56]  7 4 ⍕A[10;]
 [57]  7 1 ⍕A[11;]
 [58]  SPACE1
 [59]  'THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAME-'
 [60]  'TERS, RESPECTIVELY, FOR THREE GROUP REGRESSION.'
 [61]  7 4 ⍕A[12;]
 [62]  7 1 ⍕A[13;]
 [63]  SPACE1
```

```
[64] A[13+⍳9;]←KV6789 PSEUCORR OCI
[65] PC67←A[19 20 ;]
[66] 'THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST'
[67] 'SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.'
[68] 7 4 ⍕A[14 15 ;]
[69] SPACE1
[70] 'THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES'
[71] 'REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR'
[72] 'THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.'
[73] A[18;]
[74] SPACE1
[75] 'THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,'
[76] 'RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.'
[77] 7 4 ⍕A[19;]
[78] 7 1 ⍕A[20;]
[79] SPACE1
[80] A[23 24 ;]←STATEVEC PC67
[81] 'THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,'
[82] 'COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH'
[83] 'PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO'
[84] 'THE PRECEEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.'
[85] A[23 24 ;]
[86] R←A
```

The remaining functions in this appendix are called by the PROCESS function but are not displayed in the text of the thesis.

```
R←KV PSEUCORR OCI;A;B;C;N1;N2;X;Y;YM
⍝THIS FUNCTION USES A FOUR ROW MATRIX, KV, AND A TWO
⍝COLUMN MATRIX, OCI, AS INPUTS.  THE FIRST AND SECOND ROWS
⍝OF KV CONTAIN VECTORS OF RAYLEIGH SHAPE AND SCALE
⍝PARAMETERS, RESPECTIVELY, DERIVED BY LEAST SQUARES
⍝REGRESSION AND NOT REJECTED BY THE KOLMOGOROV TEST:  THE
⍝THIRD AND FOURTH ROWS CONTAIN VECTORS OF RAYLEIGH SHAPE
⍝AND SCALE PARAMETERS, RESPECTIVELY, DERIVED BY THREE
⍝GROUP REGRESSION AND NOT REJECTED BY THE KOLMOGOROV TEST.
⍝THE FIRST ROW OF OCI IS THE NUMERICAL REPRESENTATION OF
⍝THE CONTRACT START DATE FOLLOWED BY A ZERO.  EACH SUBSE-
⍝QUENT ROW IS COMPOSED OF THE NUMERICAL REPRESENTATION
⍝OF THE REPORT DATE AND ITS ASSOCIATED INFLATION ADJUSTED
⍝ACWP.  THIS FUNCTION COMPUTES THE PSEUDOCORRELATION, WHEN
⍝THE KOLMOGOROV TEST IS PASSED, FOR THE TWO REGRESSION
⍝METHODS, DECIDES WHICH METHOD YIELDS THE HIGHER VALUE,
⍝LISTS THE RAYLEIGH PARAMETERS WITH THE HIGHER
⍝PSEUDOCORRELATION, LISTS  THE BEST VALUES OF
⍝PSEUDOCORRELATION AND RANKS THEM.  THE OUTPUT IS A NINE
⍝ROW MATRIX WHOSE FIRST AND SECOND ROWS ARE VECTORS OF
⍝PSEUDOCORRELATION VALUES FOR LEAST SQUARES AND THREE
⍝GROUP REGRESSION, RESPECTIVELY.  THE THIRD AND FOURTH
⍝ROWS ARE VECTORS OF INDICATOR VALUES FOR COMPARISON OF
⍝PSEUDOCORRELATION BETWEEN LEAST SQUARES AND THREE GROUP
⍝REGRESSION, RESPECTIVELY, WHERE 1 DENOTES HIGHER
⍝PSEUDOCORRELATION WITH THE RAYLEIGH PARAMETERS DERIVED
⍝BY LEAST SQUARES REGRESSION AND 0 DENOTES LOWER
⍝PSEUDOCORRELATION WITH THESE PARAMETERS.  THE SIXTH AND
⍝SEVENTH ROWS CONTAIN THE VECTORS OF RAYLEIGH SHAPE AND
⍝SCALE PARAMETERS, RESPECTIVELY, HAVING THE HIGHER
⍝PSEUDOCORRELATION.  THE EIGHTH ROW CONTAINS A VECTOR
⍝OF THE BEST PSUEDOCORRELATION VALUES.  THE NINTH ROW
⍝CONTAINS THE VECTOR OF THE RANKS OF THE VALUES IN THE
⍝EIGHTH ROW.
⍝
A←3×((⍳9)=⍳9)∘.×KV[1;]=KV[1;]
B←+⌿GLOBAL∘.≤1⌽(N1+4),4×⍳⌊(÷4)×N1←1↑|OCI[;1]-⌽OCI[;1]-4
N1←1
BLOOP1:→ELOOP1×⍳N1>2
N2←1
BLOOP2:→ELOOP2×⍳N2>⍴B
→SKIP1×⍳((+/KV[(2×N1=2)+ 1 2 ;N2]≠0)=0)∨(+/B[N2])<3
X←(C←((OCI[;1]-OCI[1;1])≤GLOBAL[(B[N2])]))/OCI[;2]
C←C/(OCI[;1]-OCI[1;1])*2
YM←(÷B[N2])×+/(Y←KV[2×N1;N2]×1-*-KV[¯1+2×N1;N2]×C)
A[N1;N2]←(1-(+/(Y-X)*2)÷(+/(Y-X)*2)++/(Y-YM)*2)*0.5
→SKIP2
SKIP1:A[N1;N2]←0
SKIP2:N2←N2+1
→BLOOP2
ELOOP2:N1←N1+1
→BLOOP1
ELOOP1:A[3;]←A[1;]>A[2;]
A[4;]←A[1;]<A[2;]
A[5;]←A[3;]+A[4;]×2
A[6 7;]←((A[5 5;]=1)×KV[1 2;])+(A[5 5;]=2)×KV[3 4;]
A[8;]←((A[5;]=1)×A[1;])+(A[5;]=2)×A[2;]
A[9;]←(A[8;]≠0)\RANK(A[8;]≠0)/A[8;]
R←A
```

```
[0] R←STATEVEC PC67;S1;A;B;C;S2;S3;S4
[1] ⍝THIS FUNCTION USES A TWO ROW MATRIX, PC67, AS INPUT.
[2] ⍝THE TWO ROWS OF PC67 CONTAIN VECTORS OF THE RAYLEIGH
[3] ⍝SCALE AND SHAPE PARAMETERS, RESPECTIVELY, THAT PASSED THE
[4] ⍝KOLMOGOROV TEST AND HAVE THE HIGHER PSEUDOCORRELATION.
[5] ⍝THIS FUNCTION COMPUTES TWO STATE VECTORS.  THE FIRST
[6] ⍝STATE VECTOR CONSISTS OF THE FOLLOWING STATES:
[7] ⍝     STATE 0 - NULL HYPOTHESIS IS REJECTED./BOTH A AND K
[8] ⍝               ARE NOT WITHIN FIVE PERCENT OF THEIR
[9] ⍝               FINAL VALUES;
[10] ⍝     STATE 1 - NULL HYPOTHESIS IS REJECTED./BOTH A AND K
[11] ⍝               ARE WITHIN FIVE PERCENT OF THEIR FINAL
[12] ⍝               VALUES;
[13] ⍝     STATE 2 - NULL HYPOTHESIS IS ACCEPTED./BOTH A AND K
[14] ⍝               ARE NOT WITHIN FIVE PERCENT OF THEIR FINAL
[15] ⍝               VALUES;
[16] ⍝     STATE 3 - NULL HYPOTHESIS IS ACCEPTED./BOTH A AND K
[17] ⍝               ARE WITHIN FIVE PERCENT OF THEIR FINAL
[18] ⍝               VALUES; AND
[19] ⍝     STATE 4 - ENTIRE CONTRACT DATA SET IS UTILIZED.
[20] ⍝THE SECOND STATE VECTOR CONSISTS OF THE FOLLOWING STATES:
[21] ⍝     STATE 0 - NULL HYPOTHESIS IS REJECTED./PREVIOUS
[22] ⍝               ANNUAL A,K PAIR IS NOT WITHIN FIVE
[23] ⍝               PERCENT OF PRESENT ANNIVERSARY VALUES;
[24] ⍝     STATE 1 - NULL HYPOTHESIS IS REJECTED./PREVIOUS
[25] ⍝               ANNUAL A,K PAIR IS WITHIN FIVE PERCENT
[26] ⍝               OF PRESENT ANNIVERSARY VALUES;
[27] ⍝     STATE 2 - NULL HYPOTHESIS IS ACCEPTED./PREVIOUS
[28] ⍝               ANNUAL A,K PAIR IS NOT WITHIN FIVE
[29] ⍝               PERCENT OF PRESENT ANNIVERSARY VALUES;
[30] ⍝     STATE 3 - NULL HYPOTHESIS IS ACCEPTED./PREVIOUS
[31] ⍝               ANNUAL A,K PAIR IS WITHIN FIVE PERCENT
[32] ⍝               OF PRESENT ANNIVERSARY VALUES; AND
[33] ⍝     STATE 4 - ENTIRE CONTRACT DATA SET IS UTILIZED.
[34] ⍝THE OUTPUT IS A TWO ROW MATRIX WHOSE FIRST ROW IS THE
[35] ⍝FIRST STATE VECTOR AND WHOSE SECOND ROW IS THE SECOND
[36] ⍝STATE VECTOR.
[37] ⍝
[38] S1←(PC67=0)[1;]∧(PC67=0)[2;]
[39] A←(|PC67[1;]-¯1↑PC67[1;])<PERCENT×¯1↑PC67[1;]
[40] B←(|PC67[2;]-¯1↑PC67[2;])<PERCENT×¯1↑PC67[2;]
[41] S2←2×(A∧B∧S1)∧~S1
[42] S3←3×(~S1)∧~A∧B
[43] S4←4×(~S1)∧A∧B
[44] C←PC67
[45] C[1;]←¯1+S1+S2+S3+S4
[46] C[1;ρ+⌿C]←4
[47] A←0,(|1↓PC67[1;]-¯1⌽PC67[1;])<PERCENT×1↓PC67[1;]
[48] B←0,(|1↓PC67[2;]-¯1⌽PC67[2;])<PERCENT×1↓PC67[2;]
[49] S2←2×(A∧B∧S1)∧~S1
[50] S3←3×(~S1)∧~A∧B
[51]  S4←4×(~S1)∧A∧B
[52] C[2;]←¯1+S1+S2+S3+S4
[53] C[2;ρ+⌿C]←4
[54] R←C
```

APPENDIX C

CONTRACT INFORMATION DISPLAYS

Contract 1
Captor Mine

```
C1
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .1442  .0384  .0290
   .1384  .0427  .0336

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
     12.5     22.5     22.4
     12.4     24.0     27.9

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.708 0.483 0.375

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .1316  .0995  .2416
   .1428  .0770  .2835

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 1 1
 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .1442  .0384  .0290
    12.5   22.5   22.4

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .1384  .0427  .0336
    12.4   24.0   27.9

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .9547  .8999  .8541
   .9414  .9626  .9799

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
1 2 2

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .1442  .0427  .0336
    12.5   24.0   27.9

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 2 4
 2 2 4
```

Contract 2
CH-53

```
C2
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000 ¯.0168 ¯.0070  .0049
  .0000 ¯.0174 ¯.0073  .0046

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
      .0     ¯8.7    ¯28.6      83.4
      .0     ¯8.4    ¯28.6      88.5

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.975 0.563 0.43 0.318

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 2.0000 2.3881 2.4122  .1664
 2.0000 2.4694 2.5086  .1829

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 0 1
 0 0 0 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .0000  .0000  .0000  .0049
     .0     .0     .0   83.4

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .0000  .0000  .0000  .0046
     .0     .0     .0   88.5

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000  .0000  .0000  .9120
  .0000  .0000  .0000  .9336

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 0 2

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .0000  .0000  .0000  .0046
     .0     .0     .0   88.5

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 0 4
 0 0 0 4
```

Contract 3
F-18

```
C3
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0516 _.0041 _.0020  .0057  .0053  .0049
   .0594 ¯.0012 ¯.0001  .0039  .0051  .0050

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
    123.4·_¯991.1_ 2293.3   977.7  1008.4  1054.8
    113.1 ¯3674.0¯25898.8  1239.0  1019.0  1071.2

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.708 0.483 0.361 0.318 0.281 0.242

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .4950 1.2498  .7675  .2604  .1330  .1392
   .4455 1.0681 1.0188  .3923  .1461  .1471

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 0 0 1 1 1
 1 0 0 0 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .0516  .0000  .0000  .0057  .0053  .0049
   123.4     .0     .0  977.7 1008.4 1054.8

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .0594  .0000  .0000  .0000  .0051  .0050
   113.1     .0     .0     .0 1019.0 1071.2

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .9601  .0000  .0000  .9776  .9867  .9912
   .9648  .0000  .0000  .0000  .9820  .9949

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
2 0 0 1 1 2

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .0594  .0000  .0000  .0057  .0053  .0050
   113.1     .0     .0  977.7 1008.4 1071.2

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 0 0 2 2 4
 2 0 0 2 2 4
```

Contract 4
F-18

```
C4
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0298   .0237   .0105   .0078   .0077
  .0321   .0153   .0119   .0094   .0087

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
     93.2    110.7    194.7    237.2    230.2
     86.9    149.1    179.0    211.5    249.1

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.563 0.43 0.349 0.318 0.259

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .6652   .3243   .2658   .2310   .1722
  .6443   .4684   .2382   .1980   .2049

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 1 1 1 1
 0 0 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .0000   .0237   .0105   .0078   .0077
     .0   110.7   194.7   237.2   230.2

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .0000   .0000   .0119   .0094   .0087
     .0      .0   179.0   211.5   249.1

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000   .9855   .9928   .9921   .9959
  .0000   .0000   .9944   .9942   .9742

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 1 2 2 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .0000   .0237   .0119   .0094   .0077
     .0   110.7   179.0   211.5   230.2

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 2 2 2 4
 0 2 2 2 4
```

Contract 5
FFG-7

```
C5
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0000 _.0133 _.0053  .0006  .0008  .0045
   .0000 ¯.0134 ¯.0021  .0001  .0013  .0017

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
       .0     _6.2    _19.4    222.3    178.5     48.3
       .0     ¯6.1    ¯66.2   1111.9    128.1     99.5

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.842 0.519 0.409 0.349 0.309 0.287

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 2.0000 2.1333 2.0051  .8607  .7398  .0647
 2.0000 2.1463 1.3192  .9669  .5992  .3698

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 0 0 0 1
 0 0 0 0 0 0

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .0000  .0000  .0000  .0000  .0000  .0045
      .0     .0     .0     .0     .0   48.3

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .0000  .0000  .0000  .0000  .0000  .0000
      .0     .0     .0     .0     .0     .0

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0000  .0000  .0000  .0000  .0000  .9088
   .0000  .0000  .0000  .0000  .0000  .0000

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 0 0 0 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .0000  .0000  .0000  .0000  .0000  .0045
      .0     .0     .0     .0     .0   48.3

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 0 0 0 4
 0 0 0 0 0 4
```

Contract 6
FFG-7

```
C6
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000 -.0448 -.0056  .0017  .0052
  .0000 -.0392 -.0082  .0005  .0058

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
      .0      -.9   -27.9   136.6    64.6
      .0     -1.1   -14.3   408.6    77.4

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
1.36 0.624 0.454 0.375 0.318

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 2.000010.8403 2.0678  .6651  .1182
 2.0000 8.0462 2.8762  .8807  .1139

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 0 0 1
 0 0 0 0 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .0000  .0000  .0000  .0000  .0052
     .0     .0     .0     .0   64.6

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .0000  .0000  .0000  .0000  .0058
     .0     .0     .0     .0   77.4

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000  .0000  .0000  .0000  .9490
  .0000  .0000  .0000  .0000  .9712

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 0 0 2

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .0000  .0000  .0000  .0000  .0058
     .0     .0     .0     .0   77.4

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 0 0 4
 0 0 0 0 4
```

Contract 7
FFG-7

```
C7
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .1236  .0242  .0132  .0054  .0086
  .0441  .0300  .0130  .0049  .0070

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
    14.1     20.3     26.7     44.8     37.4
    16.7     19.2     24.6     45.8     35.6

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.708 0.519 0.409 0.349 0.301

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .3105  .2207  .1522  .2553  .1830
  .5047  .1513  .1558  .2919  .1111

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 1 1 1 1
 1 1 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .1236  .0242  .0132  .0054  .0086
   14.1   20.3   26.7   44.8   37.4

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .0441  .0300  .0130  .0049  .0070
   16.7   19.2   24.6   45.8   35.6

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .8605  .9730  .9763  .9765  .9822
  .9895  .9839  .9530  .9692  .9536

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
2 2 1 1 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .0441  .0300  .0132  .0054  .0086
   16.7   19.2   26.7   44.8   37.4

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 2 2 2 4
 2 2 2 2 4
```

Contract 8
Harpoon

```
C8
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 _.0390 _.0040  .0148
 ¯.0487 ¯.0048  .0122

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   _19.5  _267.3     83.4
   ¯15.6  ¯192.2     88.1

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.43 0.361 0.301

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 1.8049  .8128  .2930
 2.0893 1.2885  .3307

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 1
 0 0 0

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .0000  .0000  .0148
     .0     .0   83.4

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .0000  .0000  .0000
     .0     .0     .0

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000  .0000  .9683
  .0000  .0000  .0000

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .0000  .0000  .0148
     .0     .0   83.4

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 4
 0 0 4
```

Contract 9
Lamps Mk III

```
C9
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0344   .0242   .0138   .0098   .0077
  .0371   .0241   .0140   .0107   .0082

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
    65.6     87.9    123.9    145.1    163.4
    62.0     87.1    118.1    148.1    173.6

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.708 0.483 0.391 0.338 0.281

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .6483   .2465   .1563   .0931   .1688
  .6266   .2491   .1513   .0743   .1903

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 1 1 1 1
 1 1 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .0344   .0242   .0138   .0098   .0077
   65.6    87.9   123.9   145.1   163.4

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .0371   .0241   .0140   .0107   .0082
   62.0    87.1   118.1   148.1   173.6

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .8740   .9673   .9822   .9822   .9859
  .8783   .9613   .9721   .9874   .9773

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
2 1 1 2 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .0371   .0242   .0138   .0107   .0077
   62.0    87.9   123.9   148.1   163.4

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 2 2 2 4
 2 2 2 2 4
```

Contract 10
Lamps Mk III

```
C10
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0904   .0199   .0135   .0114
   .1175   .0100   .0108   .0108

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
     19.9     52.7     69.1     72.8
     22.0     66.3     65.9     65.3

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.624 0.454 0.375 0.309

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .2617   .2809   .1519   .1394
   .1753   .5274   .2101   .1215

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 1 1 1
 1 0 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .0904   .0199   .0135   .0114
     19.9     52.7     69.1     72.8

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .1175   .0000   .0108   .0108
     22.0       .0     65.9     65.3

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .9255   .9806   .9926   .9939
   .9623   .0000   .9474   .9637

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
2 1 1 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .1175   .0199   .0135   .0114
     22.0     52.7     69.1     72.8

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 2 2 4
 2 2 2 4
```

Contract 11
Lamps Mk III

```
C11
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .1614  .0249  .0215  .0114
   .1687  .0287  .0219  .0121

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
      6.3     20.1     20.6     22.7
      6.2     20.4     17.9     18.8

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.708 0.483 0.391 0.318

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .2455  .2337  .1102  .1594
   .2304  .2075  .1158  .1814

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 1 1 1
 1 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .1614  .0249  .0215  .0114
     6.3   20.1   20.6   22.7

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .1687  .0287  .0219  .0121
     6.2   20.4   17.9   18.8

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .9564  .9846  .9892  .9689
   .9612  .9720  .9751  .8867

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
2 1 1 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .1687  .0249  .0215  .0114
     6.2   20.1   20.6   22.7

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 2 2 4
 2 2 2 4
```

Contract 12
PHM

```
C12
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0472 -.0059 -.0005  .0060
   .0534 -.0041 -.0032  .0055

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
     11.5   -67.3  -877.4    97.5
     10.5   -98.2  -118.5   102.3

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.708 0.483 0.391 0.301

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .6021 1.3650  .9350  .1157
   .5632 1.2413 1.5126  .1373

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 0 0 1
 1 0 0 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .0472  .0000  .0000  .0060
    11.5     .0     .0   97.5

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .0534  .0000  .0000  .0055
    10.5     .0     .0  102.3

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .8931  .0000  .0000  .9643
   .9000  .0000  .0000  .9675

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
2 0 0 2

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .0534  .0000  .0000  .0055
    10.5     .0     .0  102.3

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 0 0 4
 2 0 0 4
```

Contract 13
TACTAS

```
C13
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0539  .0366  .0180
   .0513  .0376  .0181

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
     11.9     15.4     19.1
     12.3     15.6     18.3

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.708 0.483 0.349

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .5050  .1486  .1637
   .5218  .1411  .1655

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 1 1
 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .0539  .0366  .0180
    11.9   15.4   19.1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .0513  .0376  .0181
    12.3   15.6   18.3

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .8908  .9644  .9499
   .8861  .9751  .9308

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
1 2 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .0539  .0376  .0180
    11.9   15.6   19.1

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 2 4
 2 2 4
```

Contract 14
Tomahawk

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C14
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0000  .0122  .0126  .0090  .0064
   .0000  .0131  .0138  .0100  .0066

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
      .0   146.5   137.6   159.5   179.1
      .0   144.1   133.3   158.8   184.1

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.975 0.563 0.43 0.361 0.294

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 2.0000  .5226  .2016  .1239  .1238
 2.0000  .4986  .1734  .0993  .1375

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 1 1 1 1
 0 1 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .0000  .0122  .0126  .0090  .0064
      .0  146.5  137.6  159.5  179.1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .0000  .0131  .0138  .0100  .0066
      .0  144.1  133.3  158.8  184.1

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0000  .8556  .9169  .9266  .9298
   .0000  .8864  .9303  .9537  .9529

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 2 2 2 2

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .0000  .0131  .0138  .0100  .0066
      .0  144.1  133.3  158.8  184.1

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 2 2 2 4
 0 2 2 2 4
```

Contract 15
Tomahawk

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C15
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000   .0000   .0000 _.0028 _.0019   .0027   .0024   .0020
  .0000   .0000   .0000 ‾.0086 ‾.0006   .0027   .0030   .0019

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
.0      .0      .0      14.6    ‾58.3    50.1    51.5     53.1
.0      .0      .0      1.3     84.2    48.3    59.6     52.8

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
1.36 1.36 1.36 0.624 0.454 0.375 0.327 0.281

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 2.0000 2.0000 2.0000 2.0312  .4777   .2959   .2798   .2438
 2.0000 2.0000 2.0000 8.9176 1.2730   .2970   .3476   .2422

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 0 0 0 1 1 1
 0 0 0 0 0 1 0 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .0000   .0000   .0000   .0000   .0000   .0027   .0024   .0020
     .0      .0      .0      .0      .0    50.1    51.5    53.1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .0000   .0000   .0000   .0000   .0000   .0027   .0000   .0019
     .0      .0      .0      .0      .0    48.3      .0    52.8

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000   .0000   .0000   .0000   .0000   .9927   .9989   .9776
  .0000   .0000   .0000   .0000   .0000   .9972   .0000   .9718

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 0 0 0 2 1 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .0000   .0000   .0000   .0000   .0000   .0027   .0024   .0020
     .0      .0      .0      .0      .0    48.3    51.5    53.1

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 0 0 0 2 2 4
 0 0 0 0 0 2 2 4
```

Contract 16
Tomahawk

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C16
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .1468  .0329  .0315
  .1559  .0341  .0284

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
    12.9    27.1    30.0
    14.4    26.3    27.8

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.624 0.454 0.361

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .1412  .1577  .2373
  .1237  .1519  .2074

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 1 1
 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .1468  .0329  .0315
   12.9   27.1   30.0

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .1559  .0341  .0284
   14.4   26.3   27.8

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .8880  .9504  .9811
  .9416  .9478  .9640

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
2 1 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .1559  .0329  .0315
   14.4   27.1   30.0

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 2 4
 2 2 4
```

Contract 17
Tomahawk

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C17
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .1655  .0361  .0278
   .1773  .0380  .0308

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
     27.7     46.7     44.4
     28.1     48.1     39.9

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.708 0.483 0.361

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .1213  .1263  .2586
   .1044  .1132  .2901

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 1 1 1
 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .1655  .0361  .0278
    27.7   46.7   44.4

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .1773  .0380  .0308
    28.1   48.1   39.9

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .7776  .7691  .7175
   .8128  .8102  .6305

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
2 2 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .1773  .0380  .0278
    28.1   48.1   44.4

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 2 2 4
 2 2 4
```

Contract 18
Tomahawk

```
C18
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0000 ¯.0296  .0005  .0078
   .0000 ¯.0307  .0000  .0080

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
      .0    ¯1.6    419.1     50.9
      .0    ¯1.5 18032.8     50.9

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
1.36 0.708 0.483 0.361

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 2.0000 5.8238  .9343  .1481
 2.0000 6.2183  .9986  .1530

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 0 1
 0 0 0 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .0000  .0000  .0000  .0078
      .0     .0     .0   50.9

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .0000  .0000  .0000  .0080
      .0     .0     .0   50.9

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0000  .0000  .0000  .9719
   .0000  .0000  .0000  .9711

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 0 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .0000  .0000  .0000  .0078
      .0     .0     .0   50.9

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 0 4
 0 0 0 4
```

Contract 19
Trident I

```
C19
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
.0   .0157   .0049   .0004   .0013   .0017   .0017   .0016   .0019
.0   .0165   .0044   .0003   .0011   .0016   .0018   .0018   .0018

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
0 59.5 251.7 4430.3 1298.3   1028.6   1041.3   1062.5    984.4
0 55.0 307.0 6188.2 1497.5   1077.5   1036.3   1059.5   1084.7

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.842 0.519 0.454 0.375 0.327 0.294 0.269 0.25 0.227

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
2.0 2.5214 1.9591 .9167   .6076   .3882   .2812   .1999   .0721
2.0 2.6520 1.8220 .9383   .6571   .4107   .2591   .1599   .0785

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 0 0 0 0 0 1 1
 0 0 0 0 0 0 1 1 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
.000   .000   .000   .000   .000   .000   .000   .0016   .0019
  .0     .0     .0     .0     .0     .0     .0 1062.5   984.4

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
.000   .000   .000   .000   .000   .000   .0018   .0018   .0018
  .0     .0     .0     .0     .0     .0 1036.3 1059.5 1084.7

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
.000   .000   .000   .000   .000   .000   .000   .9687   .9776
.000   .000   .000   .000   .000   .000   .9760 .9920   .9964

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 0 0 0 0 2 2 2

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
.000   .000   .000   .000   .000   .000   .0018   .0018   .0018
  .0     .0     .0     .0     .0     .0 1036.3 1059.5 1084.7

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 0 0 0 0 3 3 4
 0 0 0 0 0 0 2 3 4
```

Contract 20
CG-47

```
C20
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000 _.0182 _.0050  .0048
  .0000 ¯.0182 ¯.0034  .0046

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
     .0    _13.6   _ 68.5    112.9
     .0    ¯13.6   ¯117.8    113.2

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.842 0.519 0.43 0.338

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 2.0000 2.6261 1.9210  .2337
 2.0000 2.6290 1.5481  .2456

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 0 1
 0 0 0 1

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
  .0000  .0000  .0000  .0048
     .0     .0     .0  112.9

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
  .0000  .0000  .0000  .0046
     .0     .0     .0  113.2

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
  .0000  .0000  .0000  .9098
  .0000  .0000  .0000  .8978

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 0 1

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
  .0000  .0000  .0000  .0048
     .0     .0     .0  112.9

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 0 4
 0 0 0 4
```

Contract 21
Sub Tender

```
C21
EACH COLUMN REPRESENTS VALUES COMPUTED AT AN ANNUAL
ANNIVERSARY OF CONTRACT START, EXCEPT FOR THE LAST
COLUMN, FOR WHICH COMPUTATIONS ARE DONE ON THE COMPLETE
DATA SET.  ZEROES DENOTE REJECTION OF THE NULL
HYPOTHESIS IN THE KOLMOGOROV TEST.

THESE ARE THE RAYLEIGH SHAPE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 -.0953 -.0273 -.0004
 -.1083 -.0280 -.0030

THESE ARE THE RAYLEIGH SCALE PARAMETERS DERIVED BY LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
     -1.6     -8.6   -977.9
     -1.3     -8.4   -118.6

THESE ARE THE VALUES OF THE KOLMOGOROV TEST STATISTIC.
0.409 0.281 0.215

THESE ARE THE COMPUTED KOLMOGOROV STATISTICS FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
 3.7391 5.0737 1.0863
 4.4753 5.2966 1.7648

THESE ARE THE KOLMOGOROV INDICATOR VALUES, 1 DENOTING
ACCEPTANCE AND 0 DENOTING REJECTION, FOR LEAST SQUARES
AND THREE GROUP REGRESSION, RESPECTIVELY.
 0 0 0
 0 0 0

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR LEAST SQUARES REGRESSION.
   .0000  .0000  .0000
      .0     .0     .0

THESE ARE THE ACCEPTED RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, FOR THREE GROUP REGRESSION.
   .0000  .0000  .0000
      .0     .0     .0

THESE ARE THE VALUES OF PSEUDOCORRELATION FOR LEAST
SQUARES AND THREE GROUP REGRESSION, RESPECTIVELY.
   .0000  .0000  .0000
   .0000  .0000  .0000

THESE ARE INDICATOR VALUES, 1 DENOTING LEAST SQUARES
REGRESSION AND 2 DENOTING THREE GROUP REGRESSION, FOR
THE METHOD HAVING THE HIGHER PSEUDOCORRELATION.
0 0 0

THESE ARE THE RAYLEIGH SHAPE AND SCALE PARAMETERS,
RESPECTIVELY, WITH THE HIGHEST PSEUDOCORRELATION.
   .0000  .0000  .0000
      .0     .0     .0

THESE ARE THE TWO STATE VECTORS.  IN THE FIRST VECTOR,
COMPARISONS ARE MADE TO THE FINAL PAIR OF RAYLEIGH
PARAMETERS, AND IN THE SECOND, COMPARISONS ARE MADE TO
THE PRECEDING PAIR OF ANNUAL ANNIVERSARY PARAMETERS.
 0 0 4
 0 0 4
```

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